PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 88TY1185	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/IB 03/06162	International filing date *(day/month/year)* 23.12.2003	Priority date *(day/month/year)* 26.12.2002
International Patent Classification (IPC) or both national classification and IPC F01N5/02		
Applicant TOYOTA JIDOSHA KABUSHIKI KAISHA		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
22.03.2004	25.02.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Nobre, S Telephone No. +31 70 340-4635

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IB 03/06162

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

2, 2a	as amended (together with any statement) under Art. 19 PCT
1, 3-21	as published

Claims, Numbers

1-10	as amended (together with any statement) under Art. 19 PCT

Drawings, Sheets

1/14-14/14	as published

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-10
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-10
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-10
	No:	Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reference is made to the following document:

D1: PATENT ABSTRACTS OF JAPAN vol. 1999, no. 09, 30 July 1999 (1999-07-30) & JP 11 122960 A (CALSONIC CORP;NISSAN MOTOR CO LTD), 30 April 1999 (1999-04-30)

The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows (cf. paragraphs [0015-0063], figs. 1 and 3):

An exhaust heat power generation apparatus comprising:
a thermoelectric converting unit (33a) that converts thermal energy of exhaust gas into electric energy;
a heat exchange unit (19) provided *on a buffer* on one surface of the thermoelectric converting unit (33a) to conduct the thermal energy of the exhaust gas that flows through an exhaust pipe; and a cooling unit (13a) provided on the other surface of the thermoelectric converting unit (33a) to cool the thermoelectric converting unit (33a).

The subject-matter of claim 1 differs from this known apparatus in that the cooling unit has a rigidity higher than the rigidity of the thermoelectric converting unit and higher than the rigidity of the heat exchange unit.

Although it is disclosed in document D1 that the cooling unit and the heat exchange unit are made of steel and that the thermoelectric converting unit is a semiconductor (implicit a ceramic material), this information is not sufficient to drawn a conclusion about the rigidity relation of these elements, as it is claim in the application.

The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

The problem to be solved by the present invention may be regarded as to provide an exhaust heat generating apparatus that overcomes the problem of insufficient contact with the thermoelectric element due to temperature oscillations. This problem is solved by the above mentioned features.

The solution to this problem proposed in claim 1 of the present application is therefore considered as involving an inventive step (Article 33(3) PCT.

Claims 2 to 10 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

converting module and the exhaust pipe/cooling unit is interfered by the thermal expansion, the heat conduction therebetween is deteriorated, decreasing the thermoelectric conversion efficiency. Especially an outer pipe of a generally employed exhaust heat power generation apparatus, to which the exhaust pipe and the cooling units are attached, is formed of a single member. The above-formed outer pipe is hardly allowed to absorb the aforementioned distortion. As a result, the distortion extends over the apparatus. If the cooling unit is formed of a water cooling system with high rigidity, it may further be difficult to absorb the distortion owing to low spring constant.

Conventionally the outer pipe of the exhaust heat power generation apparatus, to which the exhaust pipe and the cooling unit are attached, is formed of the material exhibiting low thermal expansion ratio such as a stainless steel so as to reduce the thermal distortion. The stainless steel exhibits low thermal conductivity, and therefore, high heat resistance. As a result, the thermal energy is lost during passage through the members at the high temperature and the low temperature sides before it is transferred to the thermoelectric converting module. This may deteriorate the thermoelectric conversion efficiency.

JP-A-11-122960 discloses an exhaust heat generating device interposing buffer elements between the thermoelectric element and the cooling unit in order to absorb mechanical oscillation of the supporting members due to temperature changes. However, by interposing additional material between the thermoelectric element and the cooling unit the thermoelectric conversion is deteriorated.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an exhaust heat generation apparatus with excellent thermoelectric conversion efficiency.

An exhaust heat power generation apparatus includes a thermoelectric converting unit that converts thermal energy of exhaust gas into electric energy, a heat exchange unit provided on one surface of the thermoelectric converting unit to conduct the thermal energy of the exhaust gas that flows through an exhaust pipe, and a cooling unit provided on the other surface of the thermoelectric converting unit to cool the thermoelectric converting unit. The cooling unit has a rigidity set to a highest value among those of the thermoelectric converting unit, the heat exchange unit and the cooling unit.

The exhaust heat power generation apparatus includes a system in which the thermoelectric converting unit is interposed between the heat exchange unit that conducts the thermal energy of the exhaust gas flowing through the exhaust pipe and the cooling unit such that the thermal energy is transferred. In the aforementioned system, the cooling unit has the highest rigidity. This makes it possible to allow the cooling unit to apply appropriate surface pressure to the thermoelectric converting

CLAIMS:

1. An exhaust heat power generation apparatus comprising:

a thermoelectric converting unit that converts thermal energy of exhaust gas into electric energy;

a heat exchange unit provided on one surface of the thermoelectric converting unit to conduct the thermal energy of the exhaust gas that flows through an exhaust pipe; and

a cooling unit provided on the other surface of the thermoelectric converting unit to cool the thermoelectric converting unit, wherein the cooling unit has a rigidity set to a highest value among those of the thermoelectric converting unit, the heat exchange unit and the cooling unit.

2. The exhaust heat power generation apparatus according to claim 1, wherein:

the heat exchange unit includes a heat exchange fin for conducting the thermal energy of the exhaust gas and a base having one surface on which the heat exchange unit is placed, and the other surface on which the thermoelectric converting unit is placed;

the exhaust pipe includes a main body that forms a frame of an exhaust passage to which the base is attached, and the heat exchange fin provided therein;

the exhaust passage is constructed by the exhaust pipe and the heat exchange unit; and

the base has a rigidity set to a highest value in a structure of the exhaust passage.

3. The exhaust heat power generation apparatus according to claim 2, wherein the main body of the exhaust pipe is formed of a material exhibiting a thermal expansion ratio lower than that of the heat exchange unit.

4. The exhaust heat power generation apparatus according to claim 3, wherein the main body of the exhaust pipe is formed of a stainless steel.

5. The exhaust heat power generation apparatus according to claim 2 or 3, wherein:

the main body of the exhaust pipe is provided in a center of the exhaust heat power generation apparatus, the thermoelectric converting unit is provided on an outer periphery of the heat exchange unit attached to the main body of the exhaust pipe, and the cooling unit is provided on an outer periphery of the thermoelectric

converting unit;

an elastic member is provided on an outer side of the cooling unit; and

an elastic system for fixing the thermoelectric converting unit is formed, in which a pressure is applied to the cooling unit externally by the elastic member.

6. The exhaust heat power generation apparatus according to claim 5, wherein:

the thermoelectric converting unit includes a module formed of a plurality of thermoelectric elements; and

a unit of the elastic system is structured based on the module.

7. The exhaust heat power generation apparatus according to claim 5 or 6, wherein the elastic member includes a spring and a compression member which are one of in point contact and line contact with each other.

8. The exhaust heat power generation apparatus according to claim 2, wherein the heat exchange fin in the exhaust pipe has different pitches among fins thereof.

9. The exhaust heat power generation apparatus according to claim 8, wherein the heat exchange fin is formed of a material partially exhibiting different heat conductivities.

10. The exhaust heat power generation apparatus according to claim 2 or 7, wherein each of the heat exchange unit and the main body of the exhaust pipe has a configuration such that a direction in which the base of the heat exchange unit deforms becomes opposite to a direction in which a contacting surface of the main body of the exhaust pipe deforms, the contacting surface contacting the base of the heat exchange unit.